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Generation of andesite through partial melting of basaltic metasomatites in the mantle wedge: insight from quantitative study of Andean andesites

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Continental crust in average exhibits a similar composition to arc andesites. For this reason, arc andesitic magmatism is considered to have played a key role in the generation of continental crust. However, there is still a hot debate on how andesites have acquired their geochemcial compositions. The debate is mainly centralized on the relative contributions of magma differentiation and source mixing, which reaches an impasse in the past decades. The essential reason for this kind of debates is that both of these mechanisms can account for some of the geochemical observations for andesites, leading to insufficient discrimination among them. Nevertheless, the geochemical features of andesites are primarily controlled from early to late by the composition of their source rocks in addition to partial melting and magma differentiation processes. If source mixing and partial melting processes can account for the first-order geochemical features of andesites, there is no need to invoke the processes of magma differentiation. This is illustrated by quantitative forward modeling of the geochemical data for Quaternary andesites from the Andean arc based on an integrated interpretation of these data. The modeling has run with four steps from early to late: (1) dehydration of the subducting oceanic crust at forearc depths; (2) partial melting of the subducting terrigenous sediment and altered oceanic basalt at subarc depths to produce hydrous felsic melts; (3) the generation of metasomatites (e.g., Si-excess pyroxenite) in the mantle wedge through reaction of peridotite with large amounts of the hydrous felsic melts; (4) the production of andesitic melts by partial melting of the metasomatites. The results not only testify the hypothesis that the trace element and radiogenic isotope compositions of andesites can be directly produced by the source mixing and mantle melting but also demonstrate that partial melting of metasomatites with large amounts of slab melts can reproduce the lithochemical composition of andesites. Therefore, the source mixing and partial melting processes at subarc depths can account for the first-order geochemical features of Andean andesites. In this regard, it may be not necessary for andesite petrogenesis to invoke the significant contributions from the processes of magma differentiation.